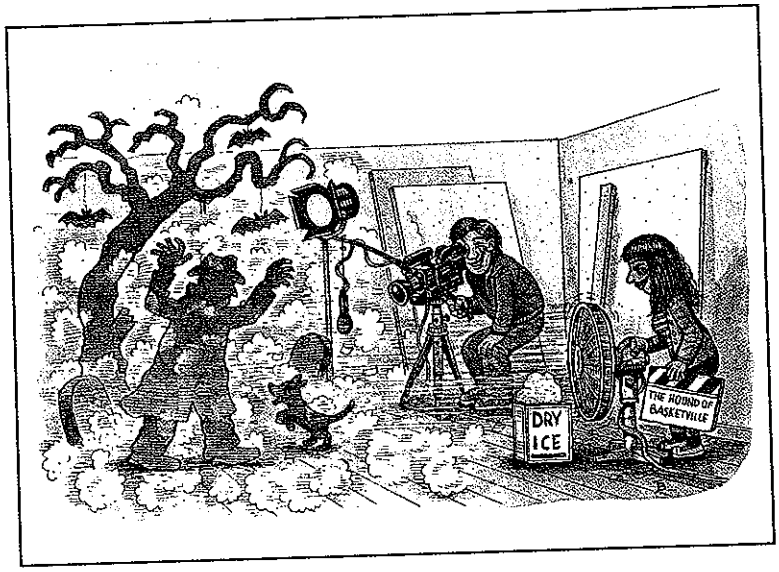
Activity 2 States of Matter: Solid, Liquid, and Gas



GOALS

In this activity you will

- Create an animation to illustrate the behavior of particles in different phases of matter, and as the material changes phase.
- Observe changes of state of water and describe the process graphically.
- Observe a change of state of carbon dioxide and describe the energy transformations involved.
- Describe the energy transformations and the roles of kinetic and potential energy as heat energy is transferred to or away from a material.
- Describe the behavior of gas particles, based on your observations of how the temperature, pressure, and volume of the gas are affected as heat energy is transferred to or away from the gas.
- Characterize materials by their unique phase-change temperatures.
- Practice safe laboratory techniques in working with temperature extremes.

What Do You Think?

You know that materials can exist as solids, liquids, or gases. Each state of matter has its own characteristics.

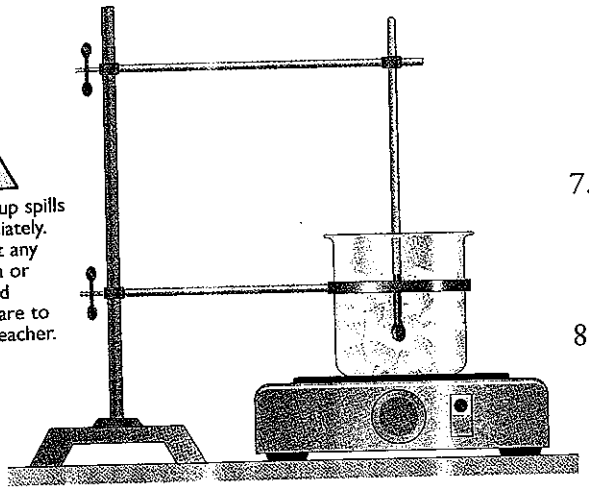
- Draw three circles. In the first circle draw what you think particles of material look like in the solid state. In the next circle draw the particles of the same material as a liquid. In the final circle illustrate the same material as a gas.

Record your ideas in your *Active Chemistry* log. Be prepared to discuss your responses with your small group and the class.

Investigate

Part A: The Heating Curve of Water

1. Put on your safety goggles and apron. Half-fill a 250-mL beaker with crushed ice.
2. Set up your equipment as shown in the diagram. The hot-plate dial should be in the off position. When you clamp the thermometer into place, be sure that the bulb is in the center of the ice and is not touching the bottom of the beaker.



lean up spills ımediately. eport any oken or acked assware to ur teacher.

3. Observe the thermometer closely until it appears to have reached its lowest reading.
   a) Prepare a data table similar to the one shown below. Record the minimum temperature at time 0 min.
4. Turn on the hot plate. Use a medium-low setting, or one suggested by your teacher.
5. Gently stir the ice and water mixture with a stirring rod.
   a) Record the temperature every minute.
6. Continue to record the temperature until the water has been at a full boil for 5 min.
   a) Name all the changes of state that you observed. A change of state refers to a change from a solid to a liquid, a liquid to a gas, a solid to a gas, and vice versa.
7. Turn off the hot plate. When the water has cooled discard it. Return all equipment as directed and clean up your station.
8. Use your data to answer the following:
   a) What was the temperature at which all the ice had melted?
   b) What was the boiling point of the water?
   c) Plot a graph of the data with time along the x-axis and temperature on the y-axis. You may wish to use a microcomputer or a calculator to plot your graph.
   d) Describe your graph. Consider: What is happening at the various points along the graph? Heat energy is being continually transferred to the system by the hot plate. At which point is the heat energy causing the temperature to increase? What is the heat energy doing if it is not acting to raise the temperature of the water?

Hot plates may remain hot for some time after they are turned off.

Never use a thermometer as a stirring rod.

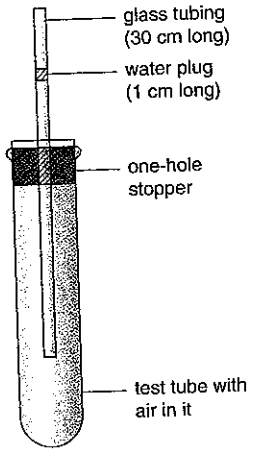
Time (min)	Temperature (°C)	Observations
0		
1		

Part B: Making Particles Shake

1. Your teacher will assemble or have you assemble a small booklet with many blank pages.
2. Use only the right-hand pages of the booklet. At the very bottom right of the last page of the booklet draw a dot. To make the dot appear to move from the top left to the bottom right at a constant speed, draw another dot on the previous page slightly to the left and up. Continue this until you reach the first page of the booklet. Now as you flip through the booklet from the front to the back, the dot will appear to move. The smaller the movements from one page to the next, the smoother the animation effect will appear.
3. Matter can be in a solid state, a liquid state, or a gaseous state. Each state of matter has its own typical motion of particles. The physical properties of each state are a result of how the particles move relative to one another. Use animation to model the movement of particles in each state of matter. Consider using different colors to keep track of the particles.
   a) In a solid the particles stay in the same position but vibrate. Use your flipbook to model the movement of particles in a solid.
   b) In a liquid the particles are about the same distance apart as in the solid, but they can move more freely. Use animation to model a liquid.
4. Gas particles are very, very far apart and they move very quickly.
   a) What problems would you have to make a flipbook for gases?

Part C: Volume Changes

1. Draw up a water plug about 1 cm long in a 30-cm long glass tube. Set the glass tubing into a test tube, as shown in the diagram below.



The water should not be too hot to touch. Glassware is slippery when wet. Handle with care.

   a) Observe and describe the movement, if any, of the water plug.
2. Place the test tube into a beaker of warm water.
   a) Record your observations in your *Active Chemistry* log.
   b) How does the warm water affect the volume of the air in the test tube? What evidence did you observe that suggested a volume change?
   c) The warm water was a source of heat energy. What effect did this heat energy have on the volume of air?

3. Place the test tube into a beaker of ice water.

   a) Record your observations in your *Active Chemistry* log.

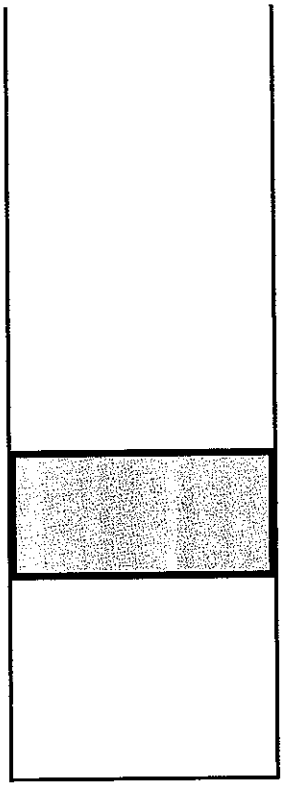
4. In physics you've learned that for the drop of water to stay in place, the forces must be equal and opposite. The force of gravity pulling down on the water plug must be equal to the upward force of the gas.

   When the air in the test tube was heated, the upward force on the water plug must have increased, because the water rose in the tube. Since no additional air molecules were added, the molecules must have moved faster as a result of the additional heat. As the temperature of the air increased, the molecules of air increased their speed and therefore applied a greater force to the drop of water. Once the drop of water rose high enough, the larger volume and fewer air molecules hitting the drop per second compensated for the increased speed of the molecules. The forces of gravity and pressure were equal once again.

   a) Pressure is force per area. What happened to the pressure on each wall of the test tube as you heated up the air (gas)?

   b) Draw a box with a moveable piston, as shown in the diagram at right.

   c) Use animation to show what would happen to the piston if the temperature of the gas inside the cylinder and below the piston were increased.



Part D: "Special" Ice

1. Your teacher will place a small piece of dry ice (solid carbon dioxide) in an empty beaker.

   a) Record your observations in your *Active Chemistry* log.

   b) Is heat energy being transferred to or away from the dry ice by the surrounding air?

   c) What change of state is taking place?